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Production of Edible White Oyster Mushroom Using Three Different Substrates

[1]Ceasar, Donellie Melisha; [2]Subramanian, Gomathinayagam; [3]Da Silva, Phillip and [4]Singh, Dharamdeo

Department of Biology, University of Guyana,
Tain Public Road, Corentyne, Berbice, Guyana

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Corresponding Author
Ceasar, Donellie Melisha
E-mail: *donellieceasar@yahoo.com*
Phone: *592-611-9504*

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ABSTRACT

The many uses of waste materials from manufacturing processes and other activities often go unnoticed. Several waste materials can be utilised in a number of ways to generate income and create employment. Agriculture based waste materials can be used in the cultivation of edible mushrooms. Edible mushrooms contain proteins and B vitamins and help to lower cholesterol, prevent diabetes, improve bone health and boost immune system function. In this study, white oyster mushroom, *Pleurotus ostreatus* was grown on three different substrates: paddy straw, nut grass and newspaper. The aim of this study was to determine which substrate was best for the cultivation and production of white oyster mushroom. The parameters monitored in this experiment were growth rate, yield and biomass. The experiment was randomized and each substrate was replicated three times resulting in a total of nine experimental units. The nut grass substrate produced mushrooms with the highest values for growth rate; it was also the first substrate to be colonized by the white oyster mushroom mycelium. Nut grass also produced mushrooms with the most fruiting bodies at time of harvesting. The newspaper substrate produced pinheads first, but it performed the least among the three substrates. Paddy straw was deemed the most suitable substrate for cultivation since this substrate produced mushrooms with the highest yield (185g) and biomass (26.67g).

INTRODUCTION

In today's society, one is often faced with the dilemma of how and where to discard of waste materials as well as how to utilize them for different purposes; especially when it comes to generating income. A waste product or substance is regarded as an unusable or unwanted material that results from a manufacturing process or any other activity (Awuchi, 2017).

In Guyana agriculture is practiced on a large-scale basis and thus large amounts of plant-based materials are usually burnt, left to decompose or are recycled for other agricultural practices.

Waste materials are often underestimated and their numerous uses often go unnoticed since, persons tend to turn a blind eye to them. These materials have enormous potential and ability to generate large amounts of income and provide employment. Mushroom cultivation, the production of mushrooms is on the rise and farmers are utilising several waste materials to serve as media on which to grow mushrooms (Islam, 2013).

Mushroom consumption is increasing worldwide because of the several health benefits that they possess (Patil, 2019). In Guyana mushroom cultivation is not practiced on a large scale and attempts are now being made to commence cultivation again since attempts in the past were futile. This research aims to utilise materials that are deemed as unusable or having little purpose to serve as substrates to cultivate white oyster mushrooms. One of the ideas behind this initiative, is not only to determine which waste material is the best substrate for mushroom cultivation, but also to highlight the fact that these waste materials that are often discarded can be used to generate income and provide jobs.

The three waste materials that were selected for this study are paddy straw, newspaper and nut grass. Most, if not all, are found in abundance throughout Guyana especially in agricultural communities.

Edible Mushrooms

Edible mushrooms as the name suggests are mushrooms that can be eaten. These mushrooms have macroscopic fruiting bodies and lack toxic poisons that may have effects on humans. Edible mushrooms play key roles in the culinary and health industries. They are cultivated mainly for their aroma, exceptional taste and numerous health benefits that they possess (Ukwuru *et al*., 2018).

As the world population increases, countries are faced with the issue of food security; thus they are constantly searching for cheap but nutritious food sources that help to contribute to healthy lifestyles and promote proper bodily functions. Thus, many persons today are moving away from consuming meat in order to pursue healthier lifestyles. Edible mushrooms are therefore an excellent food source since they are packed with several nutrients.

Edible mushrooms like the white oyster mushroom, can be substituted for meat in diets because of the amount of protein that they contain. Apart from proteins white oyster mushrooms also contain lots of vitamins like niacin (B_3) and riboflavin (B_2) as well as minerals that are essential for proper bodily functions (Link, 2018). Edible mushrooms have health benefits that help to lower cholesterol, prevent diabetes and provide antioxidant and anti-inflammatory properties.

White oyster mushrooms are a species of edible mushrooms that have a fruiting body that appear like that of an oyster. It is due to this similarity in appearance that this species got its name. White oyster mushrooms are the second most important cultivated mushrooms in the world for taste and flavor behind the button mushroom (Islam, 2013). Although, the history of cultivation for this species is unknown, white oyster mushrooms can be cultivated in different temperature ranges and climatic conditions throughout the year. White oyster mushrooms grow well on plant based dry matter and have the ability to degrade lignin, cellulose and hemicellulose. Thus, they are considered to be very easy and inexpensive to cultivate (Islam, 2013).

A comparative study on the Cultivation and Yield Performance of Oyster Mushroom (*Pleurotus ostreatus*) on Different Substrates (Wheat Straw, Leaves, Saw Dust) that was conducted by Shah, *et al* (2004), concluded that mushroom farming was a profitable agribusiness and that the substrate saw dust resulted in the highest yield. As a result, they recommended it as the best substrate to cultivate mushroom.

Another study done by Randive (2012), noted that mushroom cultivation goes hand in hand with sustainable farming and that it has several advantages. The researcher further concluded that production methods of oyster mushroom using agricultural wastes like, paddy straw and wheat straw resulted in a high yield.

Additionally, Hoa, *et al* (2015) studied the effects of different agro wastes as it relates to the yield, growth and nutritional composition of two species of oyster mushrooms; P. *ostreatus* and *P. cystidiosus* highlighted that different substrate formulas will result in differences in yield and other factors concerning the growth and development of the fungus.

On the contrary, Baysal *et al* (2003) cultivated oyster mushrooms on waste paper with added supplementary materials to evaluate yield along with several other factors. Three different supplementary materials were used; however, rice husk proved to be the most suitable since it resulted in higher yields. Chicken manure and peat however, were considered to have negative impacts on the growth of the fungus.

MATERIALS AND METHODS

Project Location

The project was conducted at the University of Guyana, Berbice Campus, John's Science Center.

Substrate preparation

Nut grass, paddy straw and newspaper were cut into small pieces of 5-6 cm in length so as to make them smaller and easier to package into the polythene bags. Each substrate was then soaked in water for ten minutes After, the prescribed time, the excess water was removed from the materials by hand squeezing them. The substrates were sterilized via an autoclave for sixty (60) minutes at a temperature of 111^{o} C and pressure of 15 psi. They were then allowed to cool in an air-conditioned environment for forty-five (45) minutes. **N.B**. The nut grass and paddy straw that were used were sun-dried beforehand.

Substrate inoculation

The white oyster mushroom spawn were obtained from the University of Guyana. The mushroom spawn used was grown on birdseed and were all the same age. The amount of white oyster mushroom spawn added to each substrate was weighed before inoculation. The substrates were placed into clear polythene bags and inoculated with mushroom spawn. The researcher placed one initial layer of substrate, evenly distributed spawn along the edge of the bag and then placed another layer of substrate on top. This was continued until the bag had three layers of substrate. Once the bag was filled, it was sealed with paper tape and the date, type of substrate, treatment number, replication number and the name of grower were recorded on it. Pinholes were made on the sides, front, top and bottom of the bags with the aid of a sterilized scissors. These steps were continued until each substrate was placed in a polythene bag and inoculated with spawn.

Pinning

After substrate inoculation, the bags were incubated at a temperature range of 23 to 25 ^{o} C in the Microbiology laboratory for pinning to occur. Pinning occurred approximately 2-3 weeks after substrate colonization. Water was added twice daily, once growth initiated.

Cropping

After pinning, the bags were transferred to the mushroom house where the temperature was maintained at a range of 25 to 27 ^{o}C. Within this environment, the mushrooms continued to grow and develop until time of harvesting. The mushrooms took approximately four (4) days to grow before reaching the criteria for harvesting. Water was added twice daily as growth continued, to maintain a moist environment.

Harvesting

The mushrooms were harvested approximately four (4) days after pinning. Harvesting was done when the cap of the mushrooms began to fold or curl inwards.

RESULTS AND DISCUSSION

Three substrates (paddy straw, nut grass and newspaper) were selected to cultivate the edible white oyster mushroom. It is believed that the type of substrate used to cultivate edible mushrooms and availability of nutrients can positively and negatively affect growth rate, biomass and yield.

The data collected during this research are presented below in graphs and a table.

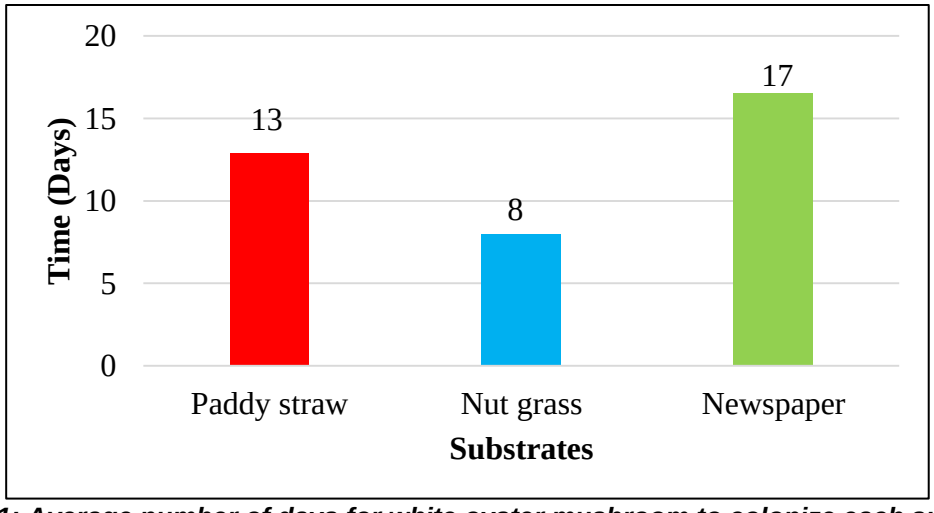

Figure 1: Average number of days for white oyster mushroom to colonize each substrate

According to the graph above it is evident that the white oyster mushroom mycelium took approximately two (2) to three (3) weeks to completely colonize the bags. Treatment 2 (Nut grass) colonized the bags in the least amount of time as compared to the other bags. Treatment 3 (Newspaper) took the greatest amount of time to colonize the bags.

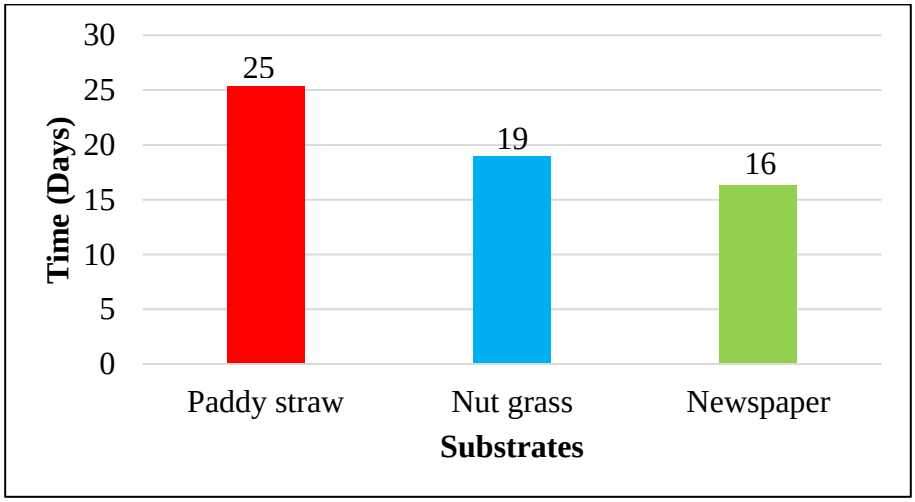

Figure 2: Average number of days for white oyster mushroom to pin

The graph above depicts the time taken for each substrate to produce pin heads. Newspaper was the first substrate to produce pin heads and nut grass the second. Paddy straw took the greatest amount of time to produce pin heads.

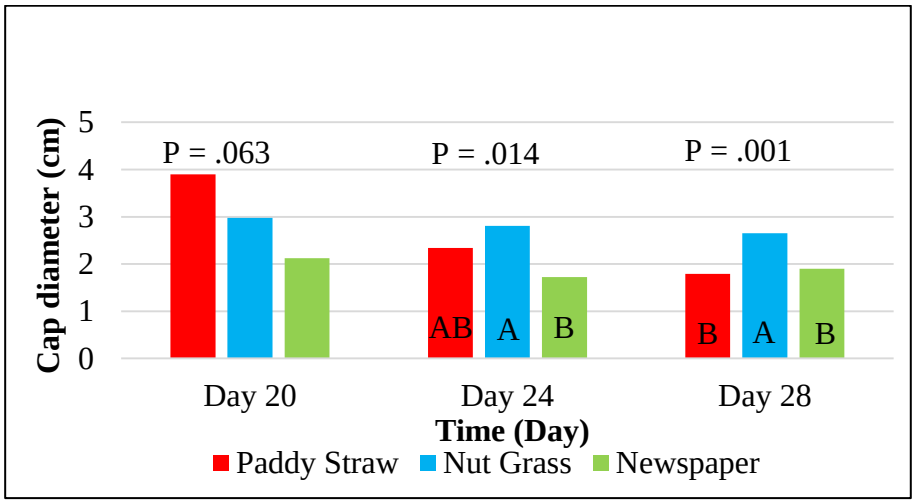

Figure 3: Average cap diameter (cm) of white oyster mushrooms grown on the three different substrates

The above graph (Figure 3) depicts the cap diameters of the white oyster mushroom grown on the three different substrates. According to the graph it is evident that there are significant differences in the diameter of the cap, at Days 24 and 28 respectively. However, there is no significant difference at Day 20. At Day 24, paddy straw is not significantly different from the nut grass and newspaper. Nut grass, however is not significantly different from paddy straw but, is significantly different from newspaper. Newspaper is not significantly different from paddy straw, however, it was significantly different from nut grass. At Day 28, paddy straw was significantly different from nut grass, however it was not significantly different from newspaper. Nut grass was significantly different from paddy straw and newspaper. Newspaper however, was not significantly different to paddy straw but, significantly different to nut grass.

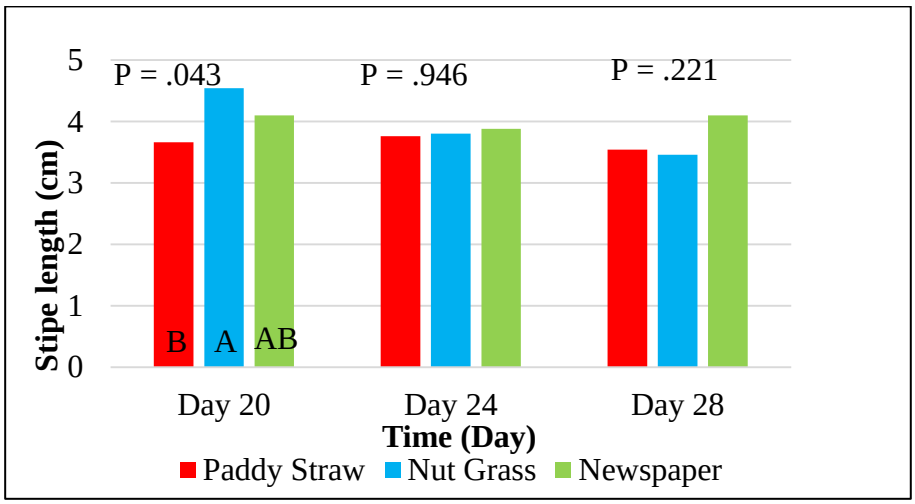

Figure 4: Average stipe length (cm) of white oyster mushrooms grown on the three different substrates

The results presented above show the mean growth rate values of the white oyster mushroom, in terms of stipe length for a period of four-day intervals. It is obvious that there are only significant differences in stipe length at Day 20. On this day, paddy straw was significantly different from nut grass, however it was not significantly different from newspaper. Nut grass was significantly different form paddy straw but, not significantly different from newspaper. Newspaper, was not significantly different from paddy straw and newspaper. At Days 24 and 28, there were no significant differences in the length of the stipes for the mushrooms.

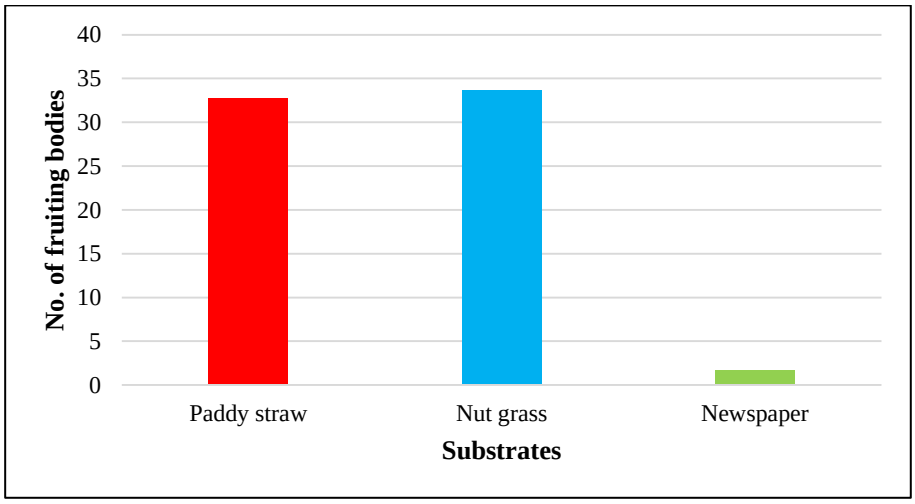

Figure 5: Average number of fruiting bodies at harvesting

The above graph (Figure 5) depicts the average number of fruiting bodies at harvesting, for the mushrooms grown in the three different substrates. The substrate nut grass, resulted in the highest number of fruiting bodies and paddy straw in the second highest. Newspaper produced the least amount of fruiting bodies.

Table 1: Average fresh weight, dry weight and P values for the white oyster mushrooms grown in three different substrates

Substrate	**Fresh weight (g)**	**Dry weight (g)**
Paddy straw	185.00 (A)	26.67 (A)
Nut grass	80.00 (AB)	25.00 (A)
Newspaper	1.67 (B)	0.28 (B)
P Value	0.039	0.028

Although nut grass produced the most fruiting bodies, it produced mushrooms with the second highest values for yield. Paddy straw produced mushrooms that had the highest yield of all the substrates, despite it had the second highest amount of fruiting bodies. However, on the contrary there were no significant differences between the biomass of the mushrooms grown in paddy straw and nut grass. It is therefore inferred that although nut grass produced mushrooms with the most fruiting bodies, it had the second highest weight and biomass because the mushrooms retained less moisture than paddy straw. If the mushrooms retain less moisture it is more likely that they will weigh less than mushrooms grown on the other substrate.

DISCUSSION

Mushroom cultivation is a very simple and inexpensive practice. Edible mushrooms can be cultivated on agricultural-based waste materials. Edible mushrooms are beneficial for the functioning of the human body because of the nutrients they contain. Mushroom cultivation can generate high incomes and be profitable.

There are several stages in the cultivation of mushrooms, all of which are important in order to ensure that the maximum amount of profit is acquired from the product. In mushroom cultivation, the colonization of bags by the mushroom mycelium is the initial step of cultivation. The time taken for the mycelium to colonize the different substrates they are grown on varies according to the substrate and the ability of the mycelium to breakdown the substrate to utilize the nutrients that it contains. From the results it is seen that the substrate nut grass was colonized first, followed by paddy straw and lastly newspaper. Colonization of the substrates occurred within the prescribed period of time, 2-3 weeks after substrate inoculation as stated by Shah, *et al* (2004) in their study to compare yield. It is suggested that nut grass was colonized at a faster rate because it contains a relatively large amount of cellulose, which is a major nutrient requirement for white oyster mushroom mycelium growth.

Pinning is the second stage in the production process of edible mushrooms. This stage is denoted by the appearance of pinheads which are small replicas of the fruiting body. Newspaper was the first substrate to produce pinheads and paddy straw, the last substrate. Pin head formation occurred 2-3 weeks after substrate colonization. These findings are in agreement with Shah, *et al* (2004), that pinning occurs 2-3 weeks after substrate inoculation. It is inferred that even though newspaper was the last substrate to be colonized it produced pin heads and fruiting bodies first because, the mushroom was able to utilize the nutrients that the material contained to produce pinheads faster than the other two substrates. Fruiting bodies were formed approximately two (2) days after pinning. Nut grass produced the most fruiting bodies of the three substrates and newspaper produced the least.

It was also recorded that nut grass and paddy straw resulted in higher growth rates. These results suggest that the white oyster mushroom has the ability to degrade and utilize the nutrients from materials that contain relatively large amounts of cellulose. White oyster mushrooms can degrade cellulose because they require it as one of the main sources of nourishment alongside hemicellulose and nitrogen for fruiting body formation and mycelium growth (Buah *et al*., 2010). Growth rates were low in newspaper because this substrate did not contain the right nutrients or sufficient amounts of the nutrients required for growth to occur at a relatively fast rate.

For farmers and growers, the harvesting of edible mushrooms is probably one of the most exciting stages of cultivation; since they can be able to know how much profit they will add to their pockets from their produce. The mushrooms were harvested approximately four (4) days after pinning when the cap began to curl or fold inwards. At harvesting, nut grass produced the highest number of fruiting bodies and paddy straw the second highest. Newspaper produced the least fruiting bodies. Nut grass and paddy straw produced more fruiting bodies because these substrates contain high amounts of cellulose, a crucial element for white oyster development (Buah *et al*., 2010).

Inspite of a slow growth rate, paddy straw is considered to be the most suitable substrate for white oyster cultivation because it produced mushrooms with the highest yield and biomass. Within the food production industry farmers and other stakeholders are interested with generating products that will result in high yield and biomass. These products tend to add more money in their pockets on the long-term basis. Suppliers are more driven to how much a product will produce and how much income it will add to their pockets on a long-term basis even if growth rates are slow. At the end of the day persons are only interested with the bigger value and the bigger results; even if less or slower means bigger or more. High yield values also mean that the product will be able to supply a large section of the population and contribute to ensuring greater food security for the increasing population (Avery, 2012).

CONCLUSIONS

According to the statistical analysis conducted to test the hypotheses; there are significant differences in growth rate, yield and biomass of mushrooms grown in the three substrates. Paddy straw was colonized at a slower rate than nut grass, which lead to pin head formation taking a longer time. This substrate produced mushrooms with the second highest amount of fruiting bodies. However, it resulted in the highest yield and biomass of white oyster mushrooms grown on the three different substrates.

The substrate nut grass produced mushrooms with the highest values for growth rate. This substrate was colonized first by the white oyster mushroom mycelium and was the second substrate to produce pin heads. Nut grass also resulted in the highest number of fruiting bodies at harvesting; however, it had the second highest yield and biomass values.

Newspaper took the greatest amount of time to be colonized by the white oyster mushroom, however pinhead formation occurred faster than the other two substrates. This substrate resulted in the mushrooms with the lowest amount of fruiting bodies at harvesting and the lowest values for growth rate, yield and biomass.

Paddy straw, was the most suitable substrate for white oyster mushroom cultivation. Although growth rate values were not the highest, it produced mushrooms with a higher yield and biomass.

Competing Interests

The author declared that there are no conflicts of interest in regards to this research.

Authors' Contributions

G.S. conceived the presented idea for the research. D.M.C was involved in the design and implementation of the research as well as data collection. D.M.C. and D.S. analyzed all data collected for the research. D.M.C. drafted the final manuscript. D.S and P.D reviewed the manuscript before submission for publication.

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REFERENCES

1. Avery, D. T. 2012. *High-Yield farming will feed the world*. Retrieved from: https://www.hudson.org/research/8960-high-yield-farming-will-feed-the-world
2. Awuchi, C. (2017). Industrial Waste Management: Brief Survey and Advice to Cottage, Small and Medium Scale Industries in Uganda. International Journal of Advanced Academic Research. 3. 26-43.
3. Baysal, E, Peker, H, Yalinkilic, M. K & Temiz, A. (2003). Cultivation of oyster mushroom on waste paper with some added supplementary materials. *Bioresource Technology*, 89(1), 95-97. Retrieved from: https://www.sciencedirect.com/science/article/pii/S0960852403000282?via%3Dihub
4. Hoa, H. T., Wang, C. L., & Wang, C. H. (2015). The Effects of Different Substrates on the Growth, Yield, and Nutritional Composition of Two Oyster Mushrooms (Pleurotus ostreatus and Pleurotus cystidiosus). *Mycobiology*, *43*(4), 423-34.
5. Islam, S. 2013. *Cultivation Techniques of Edible Mushrooms: Agaricus bisporus, Pleurotus spp., Lentinula edodes and Volvariella volvocea*. Retrieved from: https://www.researchgate.net/profile/Md_Islam183/publication/275179411_Cultivation_Techniques_of_Edible_Mushrooms_Agaricus_bisporus_Pleurotus_spp_Lentinula_edodes_and_Volvariella_volvocea/links/5534a0110cf27acb0defad0f/Cultivation-Techniques-of-Edible-Mushrooms-Agaricus-bisporus-Pleurotus-spp-Lentinula-edodes-and-Volvariella-volvocea.pdf
6. J.N. Buah, G.C. Van der Puije, E.A. Bediako, E.A. Abole and F. Showemimo, 2010. The Growth and Yield Performance of Oyster Mushroom (*Pleurotus ostreatus*) on Different Substrates. *Biotechnology, 9: 338-342.*
7. Link, R. 2018. *Oyster Mushrooms*. Retrieved from: https://draxe.com/oyster-mushrooms/
8. Patil, K. 2019. *11 Interesting Mushroom Benefits*. Retrieved from: https://www.organicfacts.net/health-benefits/vegetable/health-benefits-of-mushroom.html
9. Randive, S. D. 2012. *Cultivation and study of growth of oyster mushroom on different agricultural waste substrate and its nutrient analysis*. Retrieved from: http://www.imedpub.com/articles/cultivation-and-study-of-growth-of-oyster-mushroom-on-different-agriculturalwaste-substrate-and-its-nutrient-analysis.pdf

10. Sakur, N. 2018. *Workshop on edible mushroom and vermicomposting concludes*. Retrieved from: https://dpi.gov.gy/workshop-on-edible-mushroom-and-vermicomposting-concludes/

11. Sayner, A. 2018. *Health Benefits of Oyster Mushrooms*. Retrieved from: https://grocycle.com/health-benefits-oyster-mushrooms/

12. Shah, Z. A, Ashraf, M & Ishtiaq Ch, M. 2004. *Comparative Study on Cultivation and Yield Performance of Oyster Mushroom (Pleurotus ostreatus) on Different Substrates (Wheat Straw, Leaves, Saw Dust)*. Retrieved from: http://guerillagreen.wagn.org/files/~737/2686.pdf

13. Singh, R. P & Mishra, K. K. 2008. *Mushroom Cultivation*. Retrieved from: http://nsdl.niscair.res.in/jspui/bitstream/123456789/599/1/mushroom%20cultivation%20-%20Formatted.pdf

14. Sutherland, G. 2010. *Mushroom farming fails to catch on (This is the 10th in a series on the Grow More Food campaign)*. Retrieved from: https://www.stabroeknews.com/2010/news/guyana/11/29/mushroom-farming-fails-to-catch-on/

15. Ukwuru MU, Muritala A, Eze LU. (2018). Edible and Non-Edible Wild Mushrooms: Nutrition, Toxicity and Strategies for Recognition. *J Clin Nutr Metab* 2:2.

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